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ABSTRACT

The concept of hypertext was introduced by Ted Nelson in 1965, but only recently has the widely available technology caught up with the idea. The new generation of microcomputers featuring large internal memories, graphic interfaces, and large data storage capacities have made the commercial development of hypertext/hypermedia software possible. A review of the hypermedia concept indicates that: (1) hypermedia is based upon the philosophy of easy access to large bodies of information; (2) hypermedia should be thought of as an interactive environment for the user, not just as a single application program; and (3) end users should be able to modify hypermedia systems. As an extensive and generalized informational environment, hypermedia requires a macro level instructional design to fully utilize its capabilities. While a framework must be created to guide and structure the learner's progress, the learner must be allowed to create associations and follow related pathways and ideas. The key to building a hypermedia knowledge environment is to find the optimal balance between instruction and exploration. The elaborated resources theory, which is built upon web theory, provides a promising approach to solving this problem. Based upon the linking capabilities of hypermedia, the theory is an attempt to extend computer-based instruction beyond the tutorial approach by integrating information retrieval capacities into the hypermedia environment. It facilitates the design of hypermedia environments that can serve as tutor, tool, and tutee, enhancing both instruction and learner exploration. Diagrams illustrating the elaborated resources theory are provided. (14 references) (GL)

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# Elaborated Resources: An Instructional Design Strategy for Hypermedia

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The concept of hypertext has been brewing in the communal stew of computer consciousness since Ted Nelson first coined the term in 1965. Only recently has the widely available technology caught up with the idea. The new generation of microcomputers featuring large internal memories, graphic interfaces and large data storage capacities have made the commercial development of hypertext/hypermedia software possible.

Educators have been quick to jump on the bandwagon and begin exploring the potentials of hypermedia. In 1985 Brown University began a hypermedia project called Intermedia; Harvard is experimenting with a project for the study of the classics, Project Perseus; and USC has developed Project Jefferson, a hypertext based writing project (Kinnell, 1988).

But before charging headlong into hypermedia development, it would be useful to take a step back and reflect on what hypermedia was conceived to be, what it is, and what it could be. The purpose of this paper is to review the concept of hypermedia, and to propose a method of using hypermedia which attempts to combine the strategy of explicit instruction with the strategy of exploratory learning.

## The Idea of Hypertext

Ted Nelson proposed a system of hypertext that would allow writers to create non-sequential text utilizing multiple structures, branches, and alternatives. Readers, he claimed, would do better if they didn't have to read in sequence, but could establish impressions, jump around, or try different pathways until they found the ones they wanted to study most closely.



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Nelson's primary idea is to devise a system that more accurately reflects the natural associative linking of ideas in the human mind. Nelson also uses the term hypermedia to broaden the hypertext concept to refer to all presentational forms, which besides text, includes graphics, video images, audio, and any other sort of computer programs such as simulations, which include branching and multi-dimensional modes (1987, p. DM 64).

Since the early 1960's Nelson has been advocating hypermedia and has been trying to implement the idea in a development project called "Xanadu". Xanadu has been conceived as "...a general underlying system for all forms of interactive graphic environments" (Nelson, 1987, p. DM 144). Xanadu is a storage manager for all forms of computer information, which has the capability of linking all forms of information together. In addition, Xanadu will store all previous versions of information, making it possible for users to trace back to the original versions of documents. The system is designed to emphasize all the interconnections and commonalties among all documents.

Nelson then, conceives of hypermedia as a form of operating system, a powerful and complete networked environment for production and linking of all forms of information.

**Englebart and the Augmentation of Human Intellect**

The other "father" of the hypermedia concept is computer pioneer Douglas Englebart, the inventor of innovative computer technology such as the mouse, multiple-window screens, integrated help systems, and full-scale electronic mail systems. Englebart's work has been motivated by the belief that the purpose of computer technology is to "augment the human intellect." Computers should not be developed for their own sake or be used to replace human functioning, but should be used to increase and extend human capabilities (Englebart and Hooper, 1988).

Englebart's hypertext ideas have been tried out in at least two systems. A "Collaborative Information Domain," an electronic mail document linking system, was designed in the 1970's at Englebart's lab at SRI. The second system was an office automation project called NLS (oN Line System) that included a mouse, multiple-windows, electronic mail and teleconferencing capabilities. Renamed "Augment," it was eventually bought and marketed by McDonald Douglas as a commercial network system. (Young,1986).

**Other Definitions of Hypermedia**

Over the past three years many authors have begun exploring the idea of hypermedia and have offered their own definitions. Carr for instance, defines hypertext as "...a specific form of data retrieval..." (1988a, p. 7). It is a database "...that respond(s) to the nonlinear process of human thought....users can follow their mental processes directly through the text." (1988b, p. 66). Smith (1988) describes hypertext as an exploratory environment that allows users to follow associations that interest them. Jonassen (1986) states that hypertext is "any text presentation system that permits the user to direct the logical flow of the text presentation" (p.270). Hypertext "creates multiple pathways (structures, branches, or alternatives) for readers with different interests, permitting them to determine their own individual presentation sequence...." (p.269-270). All the authors agree, however, that hypermedia is a form of non-sequential information presentation.

**Analysis of Definitions**

Reviewing these various definitions we can derive some general ideas about the nature of hypermedia systems.

First, hypermedia is based upon the philosophy of easy access to large bodies of information. The purpose of hypermedia systems is to benefit the end user, systems must mold themselves to the user's needs, not vice versa.

Second, hypermedia should be thought of as an operating system, or better yet, as an interactive environment for the user, not just as a single application program. Hypermedia is the linking mechanism for all sorts of computerized information: documents, spreadsheets, simulations, audio, and video segments.

And finally, hypermedia systems should be able to be modified by the end users. Hypermedia should encourage users to change and remold information to more closely reflect their own cognitive structures.

**Hypermedia for Education; Nelson's Approach**

In *Computer Lib/Dream Machines,* Nelson (1987) has sharply criticized conventional Computer Assisted Instruction (CAI). Nelson argues that current CAI tends to enlarge and extend the faults of the American educational system because of its emphasis on facts set in a fixed sequence. As a result, he says, most CAI is not only boring, but suppresses initiative, narrows the curricula, and subjects learners to arbitrary testing and evaluation at the expense of individual growth.

Claiming that computers offer us the first real chance to let the human mind grow to its full potential, Nelson calls for us to reevaluate not only the structure of education but also our underlying assumptions about learning and knowledge.

> Knowledge, then–and indeed most of our civilization and what remains of those previous–is a vast cross-tangle of ideas and evidential materials, not a pyramid of truth. So that preserving its structure, and improving its accessibility, is important to us all. (p. DM 34).

The solution Nelson proposes is to build very rich, interactive learning environments and then put the student in control:

> The alternative is straightforward. Instead of devising elaborate systems permitting the computer or its instructional contents to control the situation, why not permit the student to control the system, show him how to do so intelligently, and make it easy for him to find his own way. Discard the sequences, items and conservation, and allow the student to move freely through materials which he may control. Never mind optimizing reinforcement or validating teaching sequences. Motivate the user and let him lose in a wonderful place (p. DM 133).

This ultra rich environment, which he has dubbed "responding resources," is based upon a learner controlled, discovery strategy of education. However, Nelson does not address, nor even indicate an awareness of the shortcomings of such instructional strategies. Research shows that learner control does not work for unmotivated students or those of moderate or lower ability, (Hannafin 1984, Steinberg, 1977). The proposition that exposure to an interesting, rich, interactive electronic environment will overcome the many complex factors that affect a learner's motivation and ability to learn difficult material is dubious at best.

**A Learning Theory Approach**

Jonassen (1986) has given a more extensive rationale for the use of hypermedia in instruction which is based upon research in learning theory and instruction. Jonassen notes that learning which represents subject knowledge should be postulated by both active structural networks and schema theory. A learner's prior knowledge provides the framework for constructing new knowledge, and this framework can be represented by the concept of schemata. A schemata interrelates information elements into one conceptual unit, which can then be combined to form larger units or linked to other schemata.

Web learning (Norman, 1973) is a theory which prescribes the modeling of the structure of knowledge. Web learning states that new information is integrated

into the structure of knowledge by means of associations, rather than in a linear fashion.

Jonassen states that web learning provides a key instructional principle, noting that "the effective teacher presents material in a way that allows learners the opportunity to develop some framework for relating materials to each other...and then elaborating the material." (p. 276).

**Elaboration Theory as a Basis for Design**

As an extensive and generalized informational environment, hypermedia requires a macro level instructional design to fully utilize its capabilities. A promising instructional design for this purpose can be found in the elaboration theory of instruction (Reigeluth, 1979, Reigeluth & Stein, 1983). This theory is built upon web learning theory and provides us with rich prescriptions for the design of instruction using hypertext.

The elaboration theory is an attempt to integrate much of the piecemeal knowledge we have about organizing instruction on the macro level (that is, ordering instruction across a number of objectives). It is an alternative to the standard method of organizing instruction based on a hierarchical task analysis and resulting learning prerequisites (Reigeluth 1979, Reigeluth, Merrill, Wilson & Spiller, 1980). As its name implies, elaboration theory is concerned with designing levels of instructional information which will link in an "elaborated" relationship. Thus, hypermedia and elaboration theory utilize the same basic concept as a basis for organization: elaboration theory provides us with the prescription of what to do in the organization of content and hypermedia provides us with the means for how to deliver it. In other words, hypermedia would appear to be an ideal vehicle for the delivery of instruction, and elaboration theory can spell out the design specifications that are necessary to make instruction on masses of information effective and efficient.

The overall approach of elaboration theory utilizes a general-to-detailed sequence of instruction. In other words, it involves the concept of teaching ideas initially in a greatly simplified yet "intellectually honest" form, then periodically cycling back to teach those same ideas in more complex and complete forms. As a simple example, to teach students about the topic, "the forest," you would first present them with an overview epitomizing what a forest is, containing all of its elements in a simplified view. Next you would concentrate on one element of the forest, a tree (this is known as the first level of elaboration). Once the concept of "tree" and its subcomponents has been learned you would move onto a deeper level of understanding on a particular aspect of a tree, for example its leaf (the second level of elaboration). In turn, a deeper level of study of the leaf is introduced and so on

until an appropriate level of instruction is concluded (appropriate lower levels of elaboration). Periodically, you would relate the current level of instruction back to the overview of the forest to remind the student of the relationship of the part to the whole.

In addition, the concept of an epitome is vital to the understanding of elaboration theory. An epitome is a special kind of overview or advance organizer which is designed to epitomize the subject matter of the course to be taught rather than summarize it (Reigeluth, Merrill, Wilson & Spiller, 1980; Reigeluth, 1979). The epitome is formed by "boiling down" the course content to its essence. It portrays only the most important aspects of the course content at an application level and utilizes concrete examples and practices to illustrate it.

A great amount of learner control is built into elaboration theory. Students can choose to approach the instruction horizontally, that is by viewing each topic in the epitome before progressing onto the first level of elaboration, or they can view the instruction vertically, the first topic in the epitome is viewed, then the topic's first level of elaboration is mastered, followed by the second level of elaboration and so on until all levels are completed.

Hypermedia's ability to link non-sequential information gives us the technical means for structuring and delivering instruction according to the prescriptions of elaboration theory. Going back to Nelson's original idea of hypermedia, it can be conceptualized as an operating environment, not as a single application in the strict sense of most conventional CAI. Hypermedia should be thought of as an environment to reflect the structure and content of whole bodies of knowledge. The macro emphasis of elaboration theory can form the framework to build these information structures that can model knowledge.

The key to building a hypermedia knowledge environment is to find a balance between instruction and exploration. A framework must be created to guide and structure the learner's progress, but the learner must also be allowed to create associations and follow related pathways and ideas. Hypermedia-based instruction needs to provide both structure and freedom.

## The "Elaborated Resources" Strategy

An approach to solving the problem of balancing instruction and exploration was our goal in developing the "elaborated resources" strategy. Based upon the linking capabilities of hypermedia, the elaborated resources strategy is an attempt to extend computer-based instruction beyond the tutorial approach by integrating information retrieval capabilities into the hypermedia environment.

There are three general attributes of the elaborated resources strategy:

• Instruction provides an elaboration-based tutorial, designed to teach the concepts, principles, and procedures of a topic. This tutorial will function as the instructional infrastructure for the entire learning environment.

• The developer will collect, link together, and provide access to appropriate background and supporting literature associated with the topic. This collection of literature will reflect the scope and depth of a body of knowledge.

• The instructional system provides software capabilities which will allow learners to annotate, edit, and restructure the body of knowledge to more closely reflect the learners' own ideas, interests and needs.

The elaborated resources strategy is an instructional environment that encompasses all three functions of computer based learning, as suggested by Taylor (1980): tutor, tool and tutee. In the following pages we will organize our discussion of the elaborated resources approach using this convenient and familiar structure.

**Tutor: Learning About a Network of Knowledge**

As a tutor, the elaborated resources environment operates according to the prescriptions of elaboration theory. The primary interface problem for hypermedia is the need for a map or some sort of wayfinding mechanism to illustrate the structure of the information and provide the users with access and guidance into it. The use of epitomes and the elaborated structure of the instruction can help serve these functions. The epitome, since it is supposed to be a highly inventive "simple but complete" representation of the topic can provide the necessary overview. In addition to icons and graphic maps, the epitome could also take the form of a visual metaphor or a simulation (Rezabek & Ragan, 1987). Linking allows the designer to structure the instruction into a rich, elaborated sequence, providing the user with additional wayfinding capabilities. The structure of the instruction itself, especially the emphasis of integrating information back into the epitome, provides the best wayfinding mechanism. In addition, the use of computer simulations offers a potentially powerful means for delivering the "summarize and synthesize" function at each level of elaboration. Hypermedia capabilities also allow for the addition of graphics, video, and sound to augment the basic structure of the instruction.

In addition, at appropriate points in each level of elaboration, the instruction can provide access into resource documents. This idea is based upon Nelson's concept of collateral hypertext (Jonassen, 1986). With collateral hypertext a topic may be explored from different perspectives and viewpoints by the use of compound

annotations and parallel text. For example, in an elaborated resources environment, these parallel texts would be the original documents relating to the idea or subtopic being covered. For instance, if a learner encountered a reference to "locus of control" and wanted further information, she could be linked directly to the original journal article outlining the concept. From there she could follow the history of the development of the idea by following links, or be linked to other related ideas presented in the resource documents. Clicking on another button would return her back to the instruction at the point she left. Thus, the tutorial acts as the introduction into the database of resource documents (see illustration #1).

The justification for the use of a tutorial as a "gateway" into a body of knowledge is simple. A learner needs to develop a background in the basic ideas and terminology of a new field before he can even ask the necessary questions to direct his own learning. The elaborated resources strategy attempts to overcome the limitations of the "provide the learner with a rich environment and let his natural curiosity take over" argument. It also attempts to overcome the weakness of traditional CAI: shallow levels of information presented within rigid frameworks. Once a learner has some idea of what the field is about, then he can begin to take more responsibility for exploring these ideas through the study of the original source documents. The values of exploratory, discovery-oriented, self-directed learning can be coupled with the value of efficient, effective, and reliable instruction.

**Tool: Exploring a Network of Knowledge**

The elaborated resources design can also be used as a learning tool. For learners past the beginning stage, the collected body of source documents can be used as a basic resource of information. By using a searching mechanism, similar to a traditional database, specific information can be found in the source documents. Learners can "plug themselves" into any specific part of the network of knowledge and then use links to begin exploring the information.

The advantage over a conventional full-text bibliographic database lies in the ability of the source documents to be linked back to the tutorial. If a learner, studying a source document, encounters an unknown concept or term, she can be linked back to the level of the tutorial which teaches the concept. Information can be quickly clarified. By reversing the elaborated resource sequence, learners can use it as an information retrieval mechanism to search out specific information, but still remained tied to a tutorial which can explain any unknown aspect of the document (see illustration #2).

**Tutee: Building Your Own Network of Knowledge**

Nelson conceived of hypertext as a way for users to link new information into their own knowledge process. An individual author's structure of knowledge is arbitrary and therefore may be counterproductive to individual readers. Hypertext should be malleable, allowing readers to jump around and alter it to make it more meaningful for them (Jonassen, 1986). In the elaborated resources design, learners would be encouraged to alter and add links, annotate text, and even include their own resource documents in order to build their own, personalized, network of knowledge. Hypermedia should be used to build on the synergistic effect of individuals interacting with information, filtering it through their own experience and prior knowledge, and creating fresh viewpoints and approaches to the subject. This is similar to Taylor's idea of a computer as a tutee, in which the learner's decisions and input into the computer is the prime factor structuring the output. In the end, hypermedia should be used as a tool for creating new knowledge, not just learning old knowledge.

By using the elaborated resources strategy we can design hypermedia environments that can function as a tutor, tool, and tutee. Elaboration theory allows us to structure a tutor that can utilize the non-hierarchical linking mechanisms of hypermedia while overcoming the problem of lack of guidance and synthesis. By using hypermedia as a tool, we make available extensive information resources that allows the learner to build on the basic framework of knowledge presented in the tutorial. And by utilizing the unique capabilities of hypermedia to add to and restructure the informational environment, we can encourage the learner to personalize old knowledge and create new knowledge.

**Conclusion**

Hypermedia has the technical capabilities that allow instructional designers to get beyond the limitations of developing single CAI lessons and into the business of building networks of knowledge. We can design tutorials that "train" a learner to the level necessary to handle terminology and ideas, and then support the learner's access to the resource documents that represent a collected body of knowledge. This approach has both breadth and depth of knowledge packaged into a format that is flexible and extensive.

The approach to design of instruction involving hypermedia which we have proposed in this paper is one which attempts to bridge the gap between sequenced, designed experiences which we call "instruction" and the more open-ended approaches to learning which involve the learner's exploration through resources. It seems to us that there has been a long-standing gap of both understanding as well as application between educators whose assumptions rest in one or another of these

two philosophies. Clearly, there is a great deal of energy currently behind the exploratory model for education. The high technology industry typically has an easier time seeing education proceeding along an information-rich environment (enabled by their products) than carefully designed, highly structured sequences (provided by instructional designers).

There are a number of issues raised by the synthesis which we propose. The most important in our minds is in the linking between sequenced instruction and resource documents. It is at that juncture–the innocuous little arrow in illustration 1, pointing from "instruction" to "resources–that the most critical questions emerge: program control versus learner control, needed cueing and learning guidance, and others yet to be discovered.

With regard to the learner control versus program control issue, it seems that this model places the question in a new light. The elaborated resources approach ties sequenced instruction into the sorts of open-ended learning situations with which instructional designers have typically been unable to work in the past. On the one hand, people involved with discovery learning have not tended to look at concerns of learner versus program control with any great interest and care in recent years. Exploratory learning environments can benefit, we believe, from close and careful study by instructional technologists. On the other hand, current research and development in learner control in our field takes on a new kind of significance when viewed from the perspective of resource-based exploratory learning.

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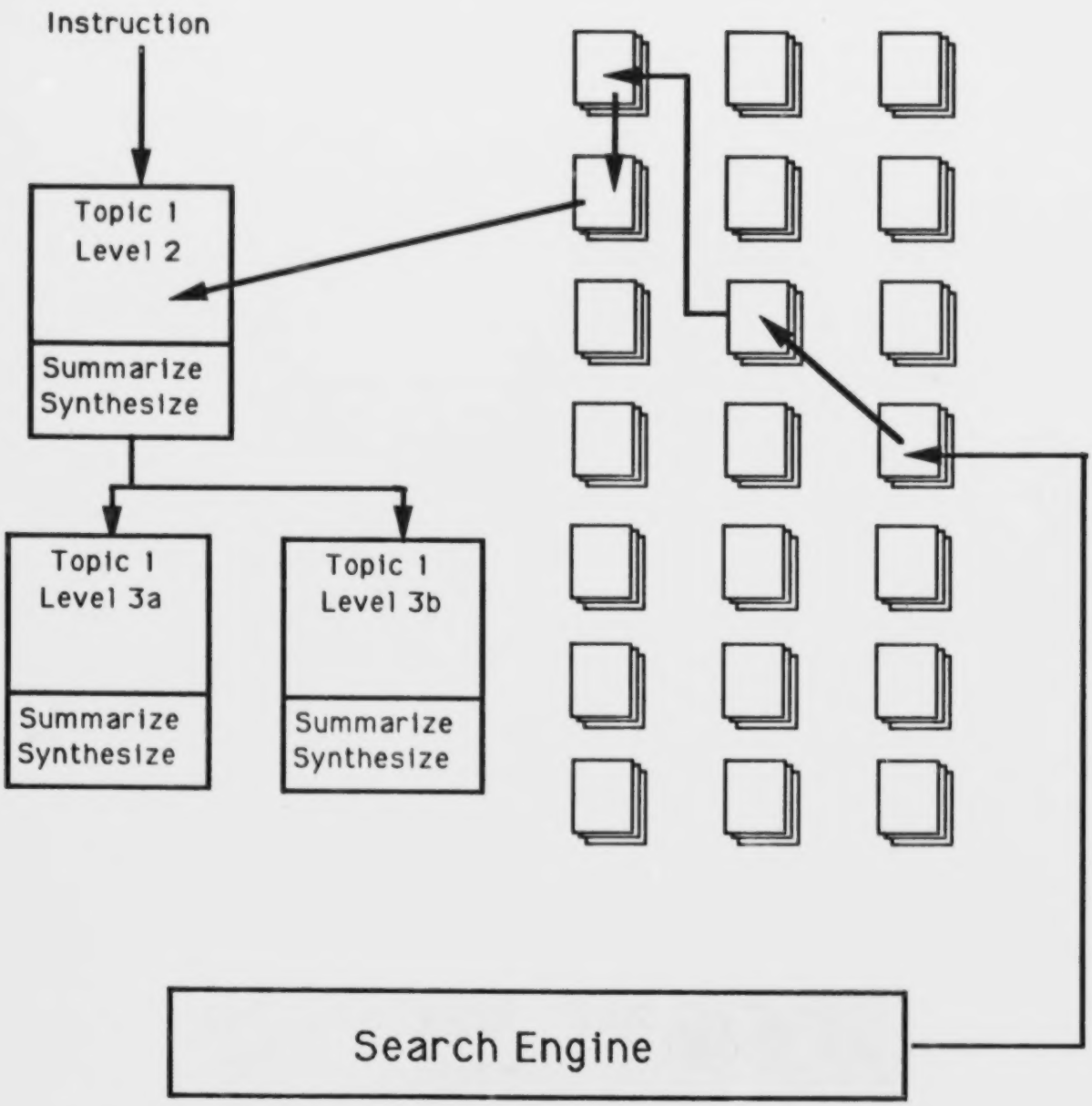


Illustration #2: Student, using an information retrieval search engine, accesses documents and follows links, then is linked back to the tutorial for explaination.

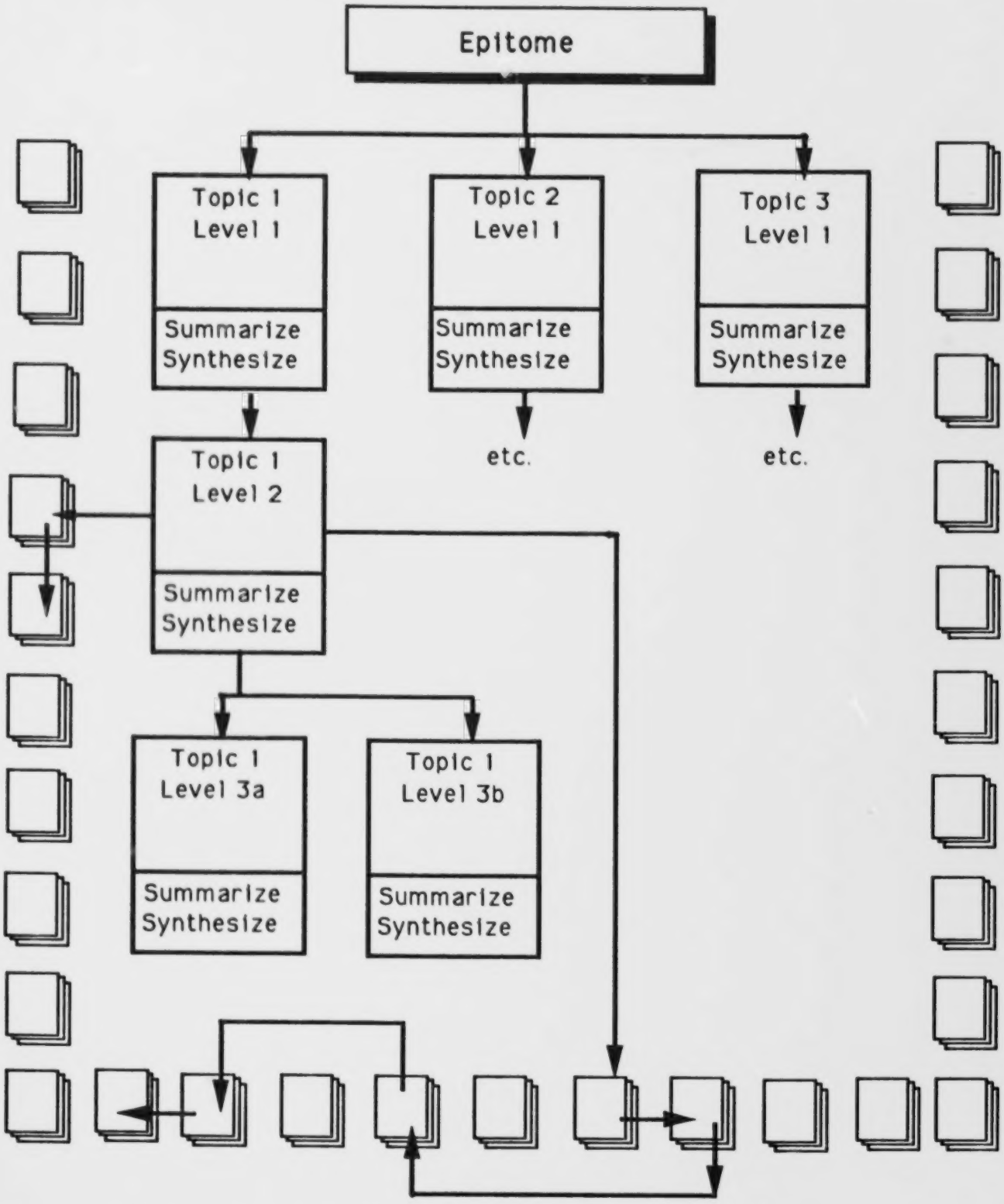


Illustration #1: An elaborated instructional design "surrounded" by a body of literature. Student is linked into a key resource document, and then follows pathway.